

APPLICATION
FOR
UNITED STATES PATENT

To Whom It May Concern:

BE IT KNOWN that We, Tetsuroh MIURA, Katsuaki MIYAWAKI, Takeshi SAITOU, Takeo SUDA, Yasushi NAKAZATO and Yasuo SUZUKI, citizens of Japan, residing respectively at 1-6-17-409, Shibamata, Katsushika-ku, Tokyo, Japan, 241-2-103, Iijima-cho, Sakae-ku, Yokohama-shi, Kanagawa, Japan, 1462-5A-706, Hazama-machi, Hachioji-shi, Tokyo, Japan, 4-7-5-504, Shiratori, Katsushika-ku, Tokyo, Japan, 5-40-1, Matsubara, Setagaya-ku, Tokyo, Japan and 3878-4, Imaizumi, Fuji-shi, Shizuoka, Japan, have made a new and useful improvement in "ELECTROPHOTOGRAPHIC IMAGE FORMING APPARATUS" of which the following is the true, clear and exact specification, reference being had to the accompanying drawings.

ELECTROPHOTOGRAPHIC IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTIONField of the Invention

The present invention relates to an electrophotographic color image forming apparatus capable of protecting images from degradation ascribable to residual toner and reversely transferred toner present on a photoconductive element and reducing blur ascribable to nitric acid and metal nitrates derived from discharge products and depositing on the photoconductive element.

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Description of the Background Art

Today, a copier, printer, facsimile apparatus or similar electrophotographic image forming apparatus provided with a cleanerless configuration, i.e., not including a cleaning unit is attracting attention from the size and cost reduction standpoint. Japanese Patent Laid-Open Publication Nos. 10-240004 and 2000-321849, for example, each propose a cleanerless image forming apparatus in which a developing unit feeds toner to a photoconductive element for forming a toner image and, at

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the same time, collects residual toner left on the photoconductive element after image transfer. On the other hand, Japanese Patent Laid-Open Publication No. 11-282320, for example, discloses a cleanerless image forming apparatus in which a brush, held in contact with a photoconductive element, temporarily collects residual toner and then returns it to the photoconductive element at preselected timing, so that the toner is collected in a developing unit. The above document teaches that the function of the brush may be assigned to a charger.

The problem with an electrophotographic image forming apparatus is that discharge from a charger, which uniformly charges the surface of a photoconductive element, produces NO_x (nitrogen oxides), ozone and other discharge products. NO_x, for example, reacts with moisture present in air to thereby produce nitric acid that, in turn, reacts with metal to produce metal nitrates. Forming a thin film on the photoconductive element, such nitric acid and metal oxides absorb moisture and thereby lower the surface resistance of the photoconductive element. As a result, a latent image formed on the photoconductive element is disturbed with the result that the resulting toner image is blurred.

While an image forming apparatus of the type including a cleaning unit can shave off the film of nitric

acid and metal nitrates with a cleaning blade, the cleanerless image forming apparatus cannot do so. In light of this, the cleanerless image forming apparatus taught in Laid-Open Publication No. 10-240004 mentioned
5 earlier uses a developing roller or an image transfer roller as grinding means for shaving off the above film.

The cleanerless image forming apparatus disclosed in Laid-Open Publication No. 2000-321849 also mentioned earlier teaches that a charger accommodates an optical
10 catalyst therein for decomposing the discharge products.

However, none of the conventional cleanerless image forming apparatuses is provided with an implementation for reducing the amount of residual toner to remain on the photoconductive element. Consequently, in the apparatus
15 of the type effecting development and cleaning at the same time, irregular charging and defective exposure become more likely to occur with an increase in the amount of residual toner, lowering image quality little by little. In the apparatus of the type using a brush, when much
20 residual toner is present or in a repeat print mode, it is likely that residual toner deposits on the brush in an amount too much to be held by the brush, aggravating irregular charging and defective exposure and lowering image quality little by little. In the repeat print mode,
25 if the residual toner deposited on the brush is returned

to the photoconductive element and then collected in the developing unit every time a preselected number of prints are output, the ability of the brush and therefore image quality may be enhanced. This scheme, however, lowers printing speed.

A color image forming apparatus has a problem that when toner images of different colors are sequentially transferred from photoconductive elements to a recording medium, intermediate image transfer body or similar subject body, a toner image already transferred to the subject body is reversely transferred to the photoconductive drums. In the cleanerless system, the toner reversely transferred brings about irregular charging and defective exposure in combination with the residual toner, lowering the image quality of the next color. Moreover, because the reverse transfer of toner occurs in the preceding step, the toner collected in the developing unit in the following step gives rise to a color mixture problem, further lowering image quality.

In a color image forming apparatus of the type developing latent images formed on a single photoconductive element with toner of different colors, the residual toner is also derived from the preceding step and therefore aggravates color mixture in the individual developing unit.

The residual toner and reverse toner transfer are ascribable mainly to the fact that the amount of charge differs from one toner grain to another toner grain. Further, the residual toner and reversely transferred toner include even toner grains charged to polarity opposite to expected polarity and unable to move in a preselected image transfer direction.

When grinding means is used to shave off the thin film of nitric acid and metal nitrates, as taught in Laid-Open Publication No. 10-240004, the grinding means shaves off the surface of the photoconductive element at the same time, causing the photoconductive element to wear little by little.

The optical catalyst scheme disclosed in Laid-Open Publication 2000-321849 has a problem that the optical catalyst must be positioned in close proximity to the surface of the photoconductive element and charger, i.e., needs an exclusive space in the vicinity of the photoconductive element and charger. Positioning the optical catalyst close to the photoconductive element and charger is contradictory to size and cost reduction achievable with the cleanerless system.

Technologies relating to the present invention are also disclosed in, e.g., Japanese Patent Laid-Open Publication Nos. 7-301977, 9-50214, 10-340030 and

2000-98855.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide
5 an image forming apparatus capable of reducing the
residual toner and reversely transferred toner for thereby
enhancing image quality.

It is another object of the present invention to
provide an image forming apparatus capable of reducing
10 nitric acid and metal nitrates ascribable to discharge
products for thereby reducing the blur of an image.

An electrophotographic image forming apparatus of
the present invention includes a photoconductive drum
provided with a photoconductive layer on its surface. A
15 charger uniformly charges the surface of the drum while
an exposing unit exposes the charged surface of the drum
to thereby form a latent image on the drum. A developing
device develops the latent image with toner by feeding the
toner to the drum to thereby produce a corresponding toner
20 image and collects residual toner left on the drum after
image transfer. An image transferring device transfer the
toner image from the drum to an intermediate image transfer
body. An air conditioning unit sends dehumidified,
air-controlled air to a space around said photoconductive
25 element.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the
5 accompanying drawings in which:

FIG. 1 is a view showing the general construction of an image forming apparatus embodying the present invention;

FIG. 2 is a fragmentary enlarged view showing an
10 image forming module included in the illustrative embodiment; and

FIG. 3 is a view showing an alternative embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 of the drawings, an electrophotographic image forming apparatus embodying the present invention is shown and implemented as a tandem color image forming apparatus by way of example. As shown,
20 the color image forming apparatus includes a casing 1 accommodating a sheet feeding section 2, four image forming modules 3, an intermediate image transfer belt, or subject body, 4, a fixing unit 5, four exposing units 6, four image transferring devices 7, and an air
25 conditioning unit 8. The sheet feeding section 2 is loaded

with a stack of sheets or recording media. The four image forming modules 3, removably mounted to the casing, each form a toner image with toner of particular color, i.e., yellow (Y), magenta (M), cyan (C) or black (K). The four
5 exposing units 6 each are assigned to one of the image forming modules 3.

The four image transferring devices 7 respectively transfer toner images formed by the four image forming modules 3 to the intermediate image transfer belt (simply
10 belt hereinafter) 4 one above the other. As a result, a full- or four-color image is completed on the belt 4. Subsequently, an image transferring device 10 transfers the full-color image from the belt 4 to a sheet fed from the sheet feeding section 2 via a registration roller pair
15 9. The sheet is then conveyed to the fixing unit 5 to have the toner image fixed thereon and then driven out to a print tray 11.

The image forming modules 3 are identical in structure except for the color of toner to use. As shown
20 in FIG. 2, each image forming module 3 includes a casing 12, a photoconductive drum or image carrier 13 disposed in the casing 12, a charge roller or contact type charger 14, a developing device 15, a humidity sensor 16, and a temperature sensor 17. The developing device 15 stores
25 toner of particular color, which is produced by

polymerization to have a uniform shape and a uniform grain size. A developing roller 15a is positioned in the developing device 15. In the illustrative embodiment, the developing roller 15a not only develops a latent image
5 formed on the drum 13 with the toner to thereby form a corresponding toner image, but also collects the toner left on the drum 13 after image transfer. The drum 13 has on its surface a photoconductive layer, not shown, which the exposing unit 6 scans with a light beam for thereby
10 forming a latent image.

Referring again to FIG. 1, the air conditioning unit 8 includes a dehumidifier, not shown, for dehumidifying air, a temperature control section, not shown, for controlling air temperature, and a fan, not shown, for
15 sending air thus dehumidified and controlled in temperature. For the dehumidifier, use may be made of structure including a case filled with a desiccant and positioned on an air flow path or a structure using a Peltier element by way of example. The temperature
20 control section may be implemented by an air conditioner, heater or similar conventional device.

The air conditioning unit 8 is communicated to the image forming modules 3 by conduits 18, so that dehumidified, temperature-controlled air is sent from the
25 air conditioning unit 8 to the image forming modules 3.

In this sense, the conduits 18 and fan disposed in the air conditioning unit 8 constitute air sending means. Air thus introduced into each image forming module 3 flows via a space around the drum 13 and charge roller 14 while
5 flowing into the developing device 15 via a filter 19 (see FIG. 2), which passes air, but does not pass toner. Subsequently, air flows out of the image forming module 3 via an opening 20 (see FIG. 2) formed in the casing 12. The drum 13 is partly exposed to the outside via the above
10 opening 20.

A valve 21 whose opening is controllable is disposed in each conduit 18. Such valves 21, humidity sensors 16, temperature sensors 17 and the dehumidifier, temperature control section and fan included in the air conditioning
15 unit 8 all are connected to a controller not shown. The controller drives the dehumidifier, temperature control section, fan and valves 21 in accordance with the outputs of the humidity sensors 16 and temperature sensors 17, so that dehumidified, temperature-controlled air is sent to
20 any one of the image forming modules 3 needing it. For example, when humidity being sensed by a given humidity sensor 16 rises above a reference value, the controller drives the dehumidifier. Likewise, temperature being sensed by a give temperature sensor 17 rises above a
25 reference value, the controller causes the temperature

control section to lower temperature. Further, in a black-and-white mode, the controller opens only the valve 21 of the conduit 18 connected to the image forming module 3 assigned to black while closing the other valves 21. As
5 a result, dehumidified, temperature-controlled air is sent only into the image forming module 3 assigned to black.

The operation of the illustrative embodiment will be described hereinafter. Toner images of different colors formed by the image forming modules 3 are sequentially transferred to the belt 4 one above the other
10 by the image transferring devices 7, completing a full-color image on the belt 4. The full-color image is then transferred from the belt 4 to a sheet by the image transferring device. After the full-color image has been
15 fixed on the sheet by the fixing unit 5, the sheet with the fixed toner image or print is driven out to the print tray 11.

More specifically, in each image forming module 3, the charge roller 14 uniformly charges the surface of the
20 drum 13. The exposing unit 6 assigned to the image forming module 3 scans the charged surface of the drum 13 with a light beam in accordance with image data, thereby forming a latent image on the drum 13. The developing device 15 develops the latent image with toner to thereby form a
25 corresponding toner image. The toner image is transferred

from the drum 13 to the belt 4 by the image transferring device 7.

Assume that some toner is left on the drum 13 after the image transfer from the drum 13 to the belt 4. Then,
5 because the surface potential of the drum 13 exposed by the exposing unit 6 differs from an image portion to a non-image portion, the residual toner in the non-image portion is transferred to the developing roller 15a during development effected by the developing device 15, i.e.,
10 collected by the developing device 15. Before the collection of the residual toner, the charge roller 14 uniformly charges the drum 13 in contact with the drum 13 and thereby unifies the charge characteristic of the residual toner, promoting efficient toner collection.

15 Further, dehumidified, temperature-controlled air sent into each image forming module 3 stabilizes humidity and temperature around the drum 13 and therefore unifies the amount of charge and adhesion of the individual toner grain. This successfully enhances an image transfer ratio
20 for thereby reducing the amount of residual toner. In addition, because the amount of charge and adhesion of the individual toner grain is uniform, the toner once transferred to the belt 4 is prevented from being reversely transferred to the drum 13, so that color mixture in the
25 developing devices 15 is obviated.

Also, by lowering temperature around the drum 13, it is possible to prevent discharge products derived from the discharge of the discharge roller 14 from reacting with moisture and producing nitric acid and metal nitrates.

5 The illustrative embodiment therefore obviates irregular charging and defective exposure ascribable to much residual toner or reversely transferred toner present on the drum 13. Also, the illustrative embodiment obviates blur ascribable to nitric acid and metal nitrates
10 otherwise forming a film on the drum 13.

Furthermore, dehumidified, temperature-controlled air output from the air conditioning unit 8 is not sent to the entire space of the casing 1, but is sent to only the image forming modules each having a small capacity.
15 This is successful to reduce the size of the air conditioning unit 8 and therefore noise and power consumption ascribable to the drive of the air conditioning unit 8.

If desired, an air conditioning unit may be disposed
20 in the individual image forming module 3, in which case the conduits 18 will be omitted. In this configuration, the air conditioning unit can be dismantled from the casing 1 together with the image forming module 3 and easily maintained.

25 An alternative embodiment of the present invention

will be described with reference to FIG. 3. In FIG. 3, parts and elements identical with those shown in FIGS. 1 and 2 are designated by identical reference numerals and will not be described specifically later in order to avoid
5 redundancy. As shown, a color image forming apparatus includes a single image forming module 23 accommodating one drum 13, one charge roller 14 and four developing devices 15 each storing toner of a particular color. The air conditioning unit 8 is communicated to the image
10 forming module 23 by one conduit 18.

In operation, toner images of different colors are sequentially formed on the drum 13 while being sequentially transferred from the drum 13 to the belt 4 one above the other by the image transferring device 7,
15 completing a full-color image on the belt 4. Subsequently, the full-color image is transferred from the belt 4 to a sheet fed from the sheet feeding section 2 by the image transferring device 10. After the full-color image has been fixed on the sheet by the fixing unit 5, the sheet
20 or print is driven out to the print tray 11.

More specifically, any one of the developing devices 15 expected to develop a latent image is moved to a respective developing position close to the drum 13. Subsequently, the surface of the drum 13 is uniformly
25 charged by the charge roller 14 and then exposed by the

exposing unit 6 with the result that a latent image is formed on the drum 13. The latent image is developed by toner fed from the above developing device 15 to become a toner image. The toner image is then transferred from
5 the drum 13 to the belt 4 by the image transferring device 7.

The toner left on the drum 13 after the image transfer is collected by the developing roller 15a during development for the same reason as described in relation
10 to the previous embodiment. Again, before the collection of the residual toner, the charge roller 14 uniformly charges the drum 13 in contact with the drum 13 and thereby uniforms the charge characteristic of the residual toner, promoting efficient toner collection.

15 Further, dehumidified, temperature-controlled air sent into each image forming module 23 stabilizes humidity and temperature around the drum 13 and therefore uniforms the amount of charge and adhesion of the individual toner grain. This successfully enhances an image transfer ratio
20 for thereby reducing the amount of residual toner. In addition, because the amount of charge and adhesion of the individual toner grain is uniform, the toner once transferred to the belt 4 is prevented from being reversely transferred to the drum 13, so that color mixture in the
25 developing devices 15 is obviated.

Also, by lowering temperature around the drum 13, it is possible to prevent discharge products derived from the discharge of the discharge roller 14 from reacting with moisture and producing nitric acid and metal nitrates.

5 The illustrative embodiment therefore, like the previous embodiment, obviates irregular charging and defective exposure ascribable to much residual toner or reversely transferred toner present on the drum 13. Also, the illustrative embodiment obviates blur ascribable to
10 nitric acid and metal nitrates otherwise forming a film on the drum 13.

 Furthermore, dehumidified, temperature-controlled air output from the air conditioning unit 8 is not sent to the entire space of the casing 1, but is sent to only
15 the image forming modules each having a small capacity. This is successful to reduce the size of the air conditioning unit 8 and therefore noise and power consumption ascribable to the drive of the air conditioning unit 8.

20 Various modifications will become possible for those skilled in the art after receiving the teachings of the present disclosure without departing from the scope thereof.